UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

URBANA, SEPTEMBER, 1919

CIRCULAR No. 236

1919 Yields From Ten Wheat Fields In "Egypt"

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Following is a report of the wheat harvest just completed on ten different experiment fields operated by the University of Illinois in southern Illinois. The results confirm those of similar reports published last year and the year before, in Circulars 229 and 208 respectively. For a more complete report of experiments conducted on these fields see Bulletin 219.

(Bushels per acre, 1919)

Soil treatment	Enfield field	Ewing field	Newton field	Oblong field	Pana field	Raleigh field	Sparta field	Toledo field	Unionville field	West Salem field	Average
Began	1913	1910	1913	1912	1913	1910	1916	1913	1911	1913	
Full[1]	1916	1912	1914	1916	1916	1912	1917	1916	1912	1915	
None.	9.2	4.8	.8	16.1	29.1	9.8	2.8	4.5	8.8	2.7	8.9
M....	8.3	5.4	1.3	20.8	31.3	10.9	3.2	6.5	10.1	11.8[2]	11.0
ML...	20.5	20.4	10.0	26.2	32.4	23.5	20.2	16.5	18.2	11.8	20.0
MLP.	24.3	21.7	14.0	32.1	33.3	24.1	20.0	20.2	26.3	19.3	23.5
R....	10.2	2.1	.5	21.3	26.7	12.6	2.3	4.7	11.0	9.7[2]	10.1
RL...	21.1	21.2	5.8	28.1	31.9	21.7	20.0	16.4	24.3	14.7	20.5
RLP..	25.8	24.7	15.2	31.3	32.9	24.7	22.5	21.5	26.7	21.8	24.7
RLPK	25.3	30.0	17.2	31.8	32.5	26.3	21.0	22.1	24.2	25.4	25.6

[1]After soil treatment is begun about one crop rotation is usually required to get the full treatment underway.

[2]Some limestone also was applied to these two plots at West Salem.

Explanatory Notes.—These fields are all under a crop rotation system, usually corn, oats, clover, and wheat, and the different plots receive treatment according to the following explanations. The farm manure (**M**) is usually applied for corn in proportion to previous crop yields. The crop residues (**R**) returned to the soil include corn stalks, straw, clover chaff, and cover crops (as sweet clover seeded on the wheat and plowed under before planting corn). Yearly acre-rates of application are 1,000 pounds of limestone (**L**), 500 pounds of fine-ground natural rock phosphate (**P**), and 200 pounds of kainit (**K**); or 4,000, 2,000, and 800 pounds, respectively, every four years. (The initial application of limestone is usually 4 tons per acre, and after four or five crop rotations the phosphate may be reduced to 200 pounds a year.)

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SOME ECONOMIC ASPECTS OF FRUIT AND VEGETABLE STORAGE[1]

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In order to understand the economics of storage, it is necessary to keep in mind certain fundamental laws regarding factors which determine the price of commodities. Except in war times, it is usually considered that the price of a given commodity at a given time and place is an expression of the ratio between supply and demand. However, the same relative change in supply affects the price of various commodities very differently. This is due to differences in the elasticity of demand for the different commodities.

The demand for some commodities is elastic, and for others it is inelastic. In the case of commodities for which the demand is inelastic, about the same quantities will be used regardless of the price, and large changes in price are associated with relatively small changes in quantities offered or taken. When the available supply is below normal, prices rise out of all proportion to the decrease in supply; and on the other hand, when the supply is above normal, prices must be enormously reduced to effect the movement of larger than the usual quantities of the given commodity. In case of a short crop, prices may reach enormous heights; and in case of an excessive crop, the selling price may be below the cost of production. In fact, in the case of a commodity for which the demand is inelastic, when the crop is in excess of the normal needs of the people the total crop will bring less money than will a crop which is below normal in volume. In general, the demand for commodities considered as neces-

[1]Revision of an address delivered at the sixty-third annual convention of the Illinois State Horticultural Society, Chicago, Nov. 21, 1918.

sities is inelastic. Relatively small changes in quantity are associated with much larger changes in price.

On the other hand, the demand for goods classed as luxuries is elastic. Relatively small changes in price are associated with relatively large changes in amounts taken. A slight reduction in price will greatly increase the amounts purchased, and a slight advance in price will greatly curtail consumption. A large crop will be of greater total value than a crop below normal in size, for the reduction in price per unit is not so great as the increase in quantity. The price of luxuries fluctuates much less widely than the price of necessities.

IMPORTANCE OF STORAGE

Storage facilities are of great importance in the handling of perishable food supplies whether the demand be inelastic or elastic. In the case of necessities, for which the demand is inelastic, storage may be made a means of distributing the supply thru the season of non-production or low production, thus making the fluctuations in price less violent. Good storage facilities make possible the anomaly of higher prices to the producer at harvest time and lower prices to the consumer during the season of non-production.

The demand for apples is elastic. A small reduction in price is likely to result in quite a large increase in quantities purchased. The converse also is true: a relatively small increase in price is likely to result in a large reduction in the quantities purchased. In order that large quantities of apples may be moved into consumption, it is therefore essential that the price be reasonable. However, it is not necessary that it be excessively low. In order that a maximum quantity be used, it is also important that supplies be available thru a long marketing season. The existence of a continuous supply on the market not only results in the moving of larger quantities because of the longer time made possible for consumption, but also has a tendency to establish the apple-eating habit on the part of more people. One reason that so many bananas are sold is that a continuous supply is available thruout the entire year. The same is true of California oranges to considerable extent. The continuous supply stimulates consumption.

The continuous supply of bananas is made possible by reason of the fact that this fruit is produced in the tropics where growth of the plants is continuous thru the year, and where by proper management of the banana plantation, it is possible to cut fruit from the trees at any time desired. In different parts of California, the climatic conditions are sufficiently different to make quite a difference in the time of ripening of the same variety of orange. It is also true that an orange will remain in good condition on the tree, in some parts of the state, for several months after it has become sufficiently

ripe for picking. By leaving the Valencia oranges on the trees thru the summer in the regions where they ripen latest, it is possible to have this variety of fruit available until the Navels of the succeeding crop in the earliest-producing regions are sufficiently mature for use. Thus, both bananas and oranges can be shipped directly from the trees to the consuming markets at any time during the year. However, if a continuous supply of apples is to be furnished at points of consumption, it is necessary that storage be resorted to for supplying the markets at least half of the year.

LOCATION OF STORAGE HOUSES

If apples must be stored for supplying the market, the question naturally arises as to whether storage should take place at the point of production or at the point of consumption. There are several advantages in having the fruit stored in the consuming regions. If the fruit is shipped to the point of consumption during the harvesting season, there is practically no danger of its freezing in transit; it is available for use at any time during the winter regardless of weather conditions, and there are no periods of local scarcity due to delayed freight movement. Furthermore, supplies for any given year may be secured directly from the most available source that year. If, on the other hand, storage in producing regions were depended upon, the storage houses in certain localities would be unused or only partially filled in seasons of light crops in a given region, unless perchance the total crop of the entire country were so large that these houses needed to be used to take up the surplus from other regions. In such a case, shipment both into and out of storage would be required, and needless movement of freight take place.

SIZE OF TOWNS THAT SHOULD STORE APPLES

The question might arise as to what sized towns could advantageously secure their winter supplies of apples in the fall and store them, rather than depend upon shipments from outside during the winter months. There are certain advantages in securing apples in carload lots. The freight rate is considerably lower than on less than carload lots, and the fruit is likely to arrive in better condition. It is particularly disadvantageous to ship in small lots during cold weather, since these are much more likely to suffer frost injury than carload lots. It would therefore be advantageous for any town which could use one or more carloads of apples to secure them in the fall and store them, provided proper facilities for storage could be secured.

A town does not need to be very large to use a carload of apples. A normal crop of apples for the United States amounts to only about two bushels for each inhabitant. This includes both summer and

winter apples and all varieties and grades. The commercial crop (the portion of the crop which is shipped beyond the borders of the county in which it is produced) is usually estimated at about 40 percent of the total crop. It is probable that on the average there would be not more than about one-half bushel of apples per inhabitant available for the winter supply. If this supply were distributed over a period of six months it would mean only about one-half of one small apple for each person each day; and yet at that rate a town of 5,000 inhabitants would require about five carloads of apples for the winter, and a town of 20,000 would require twenty carloads. In case the inhabitants of a given town really had the apple-eating habit, they could easily consume double these quantities.

Towns which can use from five to ten carloads of apples during the winter, as well as larger towns, should by all means be provided with facilities for storing their winter supply. Even as far back as 1910 there were 72 towns and cities in Illinois, outside of Chicago, with populations of over 5,000. While part of these cities have storage facilities for apples, many of them are not provided with such facilities, and in some of these places the apple supply becomes very short at times during the winter, when local shipments from distributing centers are depended upon.

The scarcity of apples and the irregularity of the supply in winter is even more pronounced in smaller towns. According to the Census Report for 1910 there were 245 towns and cities in Illinois with populations of between 1,000 and 5,000. The number has increased rather than diminished since that time. Since 1,000 people can use a carload of apples during the winter if each person eats one apple every two days, large quantities of apples in the aggregate would be needed to supply the towns of Illinois having populations of 1,000 to 5,000, if they used their rightful share of the apple crop. However, during periods of severe weather, such towns sometimes are entirely without apples, except those shipped in by express at enormous expense. Under such circumstances, the high retail price curtails consumption. This condition could be overcome by the maintenance of proper storage facilities in these towns.

STORAGE FOR LOCAL CONSUMPTION IN PRODUCING REGIONS

Thus far we have been thinking primarily of towns located outside of commercial apple-producing regions; but even in localities from which apples are shipped in large quantities at harvest time, a supply for winter use is often lacking. This is especially true in the smaller towns. Apples may be very abundant in September and October, but practically none available after the first of December, except as an occasional barrel is shipped in from a storage house in

some more or less distant city. This means that whatever apples are consumed in that town in the winter have usually had to be shipped to and from storage, thus necessitating the inclusion of two transportation charges in the retail price. If local storage facilities were available, no freight or express charges whatever would be necessary; and there is no doubt but that many more apples would be used in such towns if they were stored locally. It is exceedingly regrettable that inhabitants of towns in apple producing regions do not have an opportunity to enjoy the products of their own locality during the winter as well as at harvesting time.

TYPES OF STORAGE STRUCTURES FOR APPLES

To meet the storage requirements of towns of various sizes, different sorts of storage structures need to be provided. It must be kept in mind that three factors have a distinct bearing upon the keeping quality of apples in storage, aside from the condition of the fruit itself when placed in storage. These factors are temperature, humidity, and aeration. Up to the present time more attention has been given to temperature than to the other two factors. However, the experience of persons who have given attention to the matter of humidity indicates that this may be fully as important a factor as temperature, and the results of recent investigations by Brooks and Cooley[1] indicate that aeration is the most important factor in relation to apple scald.

Where apples are to be stored in a large city there is little question but that mechanical refrigeration is the most convenient and satisfactory method of maintaining the desired temperature. In a city of considerable size where artificial ice is used in quantity, the apple storage house may very appropriately be operated in connection with the ice manufactory. Such a storage plant, however, demands expensive equipment and skilled operators, and in a medium-sized town where ice is not manufactured, it would hardly be feasible to erect a mechanical refrigeration plant for the storage of a few carloads of apples. In a place of this sort, an ice-cooled storage house would better fulfil the requirements. Such a house needs no expensive machinery or equipment, and with proper attention to ventilation can be operated so that a practically uniform temperature of 33° F. can be maintained. A storage house of this type, built at Neoga, Illinois, by the Horticultural Department of the University of Illinois, was successfully operated for a number of years.[2] While the

[1] Journal of Agricultural Research, Vol. XI, No. 7.

[2] Plans and specifications of this storage house were presented to the Illinois State Horticultural Society by Professor J. C. Blair, in 1901, and published in the Transactions of the Society for that year.

temperature was two degrees higher than that usually maintained for apples in a mechanically cooled storage plant, the fruit kept fully as well as in the latter type of storage. The exceedingly slight amount of shrinkage due to loss of moisture from the fruit was especially noticeable. It is probable that the melting ice resulted in a more humid atmosphere which kept the fruit from shrinking.

The only objection to such a store house is that it requires ice, and ice is rather expensive in these days. Such a house could be economically operated where ten to twenty carloads of fruit are to be stored. For small towns, needing perhaps only one, two, or three cars of apples for the winter supply, another type of storage would be cheaper to operate and would serve the purpose quite well, particularly in regions where the weather is fairly cool at the time apples are placed in storage. Under such circumstances, an outdoor cellar provided with means for controlling both the humidity and the aeration would probably be the most satisfactory type of storage house. Such a structure is particularly desirable for maintaining a winter supply of apples for small towns in apple-producing regions, and furnishes the most practical means of solving the question of a winter supply of fruit for such places. If every apple-producing locality in Illinois were supplied with storage facilities of this sort, it would improve not only the health of the inhabitants of these localities, but also the general condition of the apple market in the larger places.

A big advantage in thus storing apples for local use would be that the expense for barrels could be eliminated, since with proper control of humidity and aeration, the apples could be stored in open crates, or possibly even in bulk. Thus a local supply in producing regions could be made available thru a large part of the winter with little expense for packages, and no expense for freight.

An outdoor cellar of the type suggested can be taken care of without much trouble. It is true that the temperature cannot readily be held at quite so low a point as in an ice-cooled house or a mechanical refrigeration plant. However, after winter weather sets in, it is feasible to hold the temperature between 34 and 38° F., and the control over humidity and aeration will offset to some extent the disadvantage of the higher temperature.

A storage for winter supplies for a small town might readily be owned and operated by a wholesale dealer in case there is one in the town. In towns where there are no wholesale dealers, there is often an association of retail merchants. Such an organization might readily form a stock company for the construction and operation of a store house where all members could store the apples needed for their retail trade thru the winter. For supplying small towns in apple-producing regions, some progressive grower might very well construct a storage cellar on his farm and supply the various retailers with

apples as they needed them thru the winter, in case the dealers themselves were without proper storage facilities.

CONSTRUCTION OF AN OUTDOOR CELLAR

Since the outdoor cellar constitutes the type of storage best adapted to the needs of small towns, or individual growers desiring to supply these towns, a brief consideration of the construction of such cellars may not be out of place.

"An outdoor cellar is ..... preferably built in a hillside and fully covered with earth except at one end where the entrance is located. Ventilation is provided for by means of large ventilator shafts thru the roof, and cold air intakes under the floor. In addition to being located where the natural drainage is good, thoro drainage is provided by placing a line of tile around the outside wall and also having the air intake serve as a drain for surplus water that might in any manner gain access to the cellar. If the air entering the intake is made to pass over a reservoir of water under the floor of the cellar, the proper degree of humidity ..... can be maintained.

"Such an outdoor cellar may be constructed of brick, hollow tile, or concrete. Taking advantage of the topography of the land, an excavation is made at such a point that a grade entrance will be secured to the cellar, if possible. Forms are then erected, if the construction is to be of concrete, and the side walls made. The roof may be either in the form of an arch that is self-supporting, or it may be made flat if reinforced concrete construction is employed. Provision must be made for carrying the ventilator shafts of concrete to a height that will put their outlets above the layer of earth that is to be placed over the roof. It is preferable to have the walls provided with air spaces to furnish insulation. For this purpose concrete blocks in place of solid concrete walls may be employed. Another way of improving the insulation of the storage cellar is to fill in a layer of cinders between the concrete wall and the bank of earth forming the side of the excavation, and also to carry the layer of cinders over the roof. In all cases there should be a layer of water proof concrete over the roof.

"Earth should be banked against the exposed sides and over the top of the building to a depth of at least three feet."[1]

STORAGE OF POTATOES AND ROOT CROPS

Thus far we have been speaking primarily of storage as applied to the apple. However, it should be stated that the type of outdoor cellar just described affords exceptionally good storage facilities for

[1]From Circular 231 of this station, "Storage of Vegetables for Winter Use," September, 1918.

potatoes and root crops. These cellars show their superiority over other forms of potato storage most strongly when the stock is kept until late spring or early summer. The remarks previously made in reference to the desirability of shipping apples at harvest time to the points of consumption, are equally applicable to potatoes. Towns which consume a few carloads of potatoes each winter should not be obliged to depend upon shipments from northern producing regions or large distributing centers during the dead of winter. It would be highly advantageous to store the entire winter's supply as early in the fall as the maturity of the crop and the available car supply will permit.

A normal crop of potatoes in the United States amounts to only about four bushels for each inhabitant. If each person in a town consumed his full share on this basis, it would involve the storage of about two bushels per capita for a six-months' winter supply. This would mean that a town of 5,000 inhabitants would need about twenty carloads of potatoes. Even if only half this quantity were used in a given town of the size mentioned, it would be highly advantageous to have storage facilities that would enable the town to ship in its full supply before severe winter weather sets in.

While an outdoor cellar of the type described is especially suitable for the storage of relatively small volumes of apples or potatoes, such a cellar may be constructed of almost any desired size by putting in sufficient pillars for supporting the roof. Such a cellar may therefore be used for storing large supplies of potatoes and root crops.

SUMMARY

The most important storage problems for Illinois involve questions of economics rather than questions of refrigeration.

Apples constitute a commodity for which the demand is elastic. Large quantities can be sold at remunerative prices provided supplies are continuously available at all consuming markets and people are thus encouraged to establish the apple-eating habit. Storage at the points of consumption will make it possible to keep the supply continuous. Not alone should the large cities be provided with storage facilities; small towns outside of producing regions should have apples in winter without paying express rates for their transportation. Small towns in producing regions should have them without much expense for packages, and with no expense for freight.

The maintenance of suitable storage facilities in the smaller markets will decrease the cost of distribution and increase the consumption of fruit and vegetables.